DOCUMENT RESUME

ED 149 169 CE 014 582

AUTHOR	Banks, Wilson P.; And Others
TITLE	Implementing the Metric System in Personal and Public Service Occupations. Metric Implementation Guide.
INSTITUTION	Illinois State Univ., Normal. Dept. of Mathematics.
SPONS AGENCY	Illinois State Office of Education, Springfield. Div. of Adult Vocational and Technical Education.
PUB DATE	[77]
NOTE	67p.; For related documents see CE 014 580-584
EDRS PRICE	MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS	Instructional Materials; *Learning Activities; *Metric System; Occupational Home Economics; Public Service Occupations; *Service Occupations; Teaching Guides; *Teaching Procedures; Teaching Techniques; Vocational Education

ABSTRACT

Addressed to the personal and public service occupations teacher, this guide is intended to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding presentation of the material in the classroom. An introductory section on teaching suggestions emphasizes the need for a "think metric" approach made up of hands-on experience with the use of convenient referents (models for some of the commonly used units) but very little conversion between the metric system and the customary system. Major contents are in eight chapters: (1) The System, (2) Length, (3) Area, (4) Volume (Cubic Measure and Liter Measure), (5) Mass, (6) Volume-Mass, (7) Other Units (Temperature, Force, Energy-Work, Power, Pressure-Stress, and Torque), and (8) Miscellaneous Exercises. Each chapter includes explanatory material and a variety of suggested learning activities, some with directions addressed to the student. Some activities and exercises are of a general nature and some are related to specific occupational areas: child care, industrial sewing, food management, production and services, interior decorating, cosmetology, and environmental control. A bibliography and answers to the exercises are appended. (JT)

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ED149169

METRIC IMPLEMENTATION GUIDE

IMPLEMENTING THE METRIC SYSTEM

IN

PERSONAL AND PUBLIC SERVICE OCCUPATIONS

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Project Funding Agency:
Illinois Office of Education
Department of Adult, Vocational and Technical Education
100 N. First Street
Springfield, Illinois 62777

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FOREWORD

This book is intended to guide vocational-technical educators in the implementation of the metric system in the classroom. It is not an official or complete presentation and discussion of the system. Indeed, only a small portion of the metric system is appropriate for discussion in this document and for vocational-technical instruction. Books and documents are available which do present the official position for the use of the metric system in its entirety.

Through the years there have been many systems of measure labeled "the metric system," so it is important to understand which such system is meant when the term metric system is used. The U. S. Metric Conversion Act of 1975 declared that the system to be followed was the International System of Units as established by the General Conference of Weights and Measures in 1960, otherwise known as SI (Systeme Internationale). It is the SI to which professional, industrial and educational associations, governmental and educational agencies, and business enterprises are now converting.

In most countries of the world some segment of the society has used a metric system. It is likely, however, that at least some elements of that system do not conform to the SI. For example, in this country metric units have been used in the sciences and taught in science classes for years, but in large part they have been cgs (centimeter, gram, second) units, whereas the SI is a mks (meter, kilogram, second) system. This means that the dyne and other units in the cgs system are not accepted for use in the SI. The quintal (100 kilograms), used in Europe and somewhat in the U. S., is metric but is not acceptable

for use in the SI. The micron (0.001 millimeter) is another example of a metric unit which is not an SI unit. The U. S. Government has formed a committee to guide in the conversion from the traditional system to the SI but it may be some time before certain practices and policies are agreed upon and adopted large-scale in this country.

In this book attention is focused primarily on SI. Secondarily, attention is given to other metric units and customary units, and their relationship to SI.

ACKNOWLEDGMENTS

One of the functions of the Mathematics Department of Illinois State University is to engage in projects which will improve the effectiveness of elementary, secondary and post-secondary, and teacher education programs. Another function is to serve the citizens of the State of Illinois. Both functions are combined in the preparation of this Metric Implementation Guide, for the guide should ease the transition to the metric system (SI) of measurement for students and those employed in personal and public service occupations.

Measurement is a mathematical topic, but its use in personal and public service occupations is best known by practitioners and educators in that field. The authors are deeply grateful to Daniel Swanson and Charlotte Upton for their assistance in gathering information for publication. Sincere thanks are extended to Virginia Dorn, Bessie Hackett, Susan Kern, Vesta Morgan, and Jack Williams for their helpful examination of drafts of this guide.

Gratitude is expressed to two IOE members: Gene Beenenga, for his assistance at every stage of the development, and Peggy Pool, for her logistic assistance. Special appreciation and gratitude go to Marilyn Parmantie for her tireless and efficient work in manuscript preparation.

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IMPLEMENTING THE METRIC SYSTEM IN PERSONAL AND PUBLIC SERVICE OCCUPATIONS

Measurement practices in the personal and public service occupations may not change as rapidly as those in other vocational-technical occupations. Students in the personal and public service occupations are likely to require very little more knowledge of the metric system than the ordinary citizen. Of course, the technical journals and research journals in many of these fields have used the metric system for quite some time.

Changes are evident, however. For some time manufactured food products have had the amount of the packaged contents identified by a customary (English) unit and also by a metric unit. A can of baked beans is labeled 1 pound and also 453.6 grams; a bottle of vinegar is labeled as 1 quart or 32 fluid ounces and also 0.956 liter.

Newspapers and other media have implied that as we change to the metric system we must also change cooking practices. Apparently because Europeans weigh their food ingredients in metric units it is thought that we must also. This is not true. The volume method for measuring ingredients may be employed as has been traditional. Volumes will be measured in liters and milliliters instead of cups, ounces, teaspoons, etc. On the other hand, if recipes become commonly available which give the mass (weight) of each ingredient, people may wish to utilize a convenient kitchen balance. Experiments have shown that this method is actually faster.

It will not be long before the impact of the changeover will be felt in personal and public service occupations. It is therefore appropriate and important to prepare all students for this development now.

Teaching Suggestions

The primary goal in teaching the metric system is--think metric. All of the activities and instructional procedures should be designed with that goal in mind. Teaching activities which are primarily lecture or teacher-focused, therefore, are inadvisable. Activities which emphasize measuring, estimating and thinking in the system are far more valuable. Filmstrips and overhead transparencies, commercially produced or otherwise, are of limited value. In fact, few of these filmstrips and transparency packets are without serious error and most are quite expensive. Worse, however, is that the use of these materials is deficient in the same way that lectures are deficient--the student is only a passive participant.

Hands-on Experience

The main emphasis of instruction should be on experiences in actually measuring, estimating and thinking metric. For example, after students become acquainted with the meter and its subunits (particularly decimeter, centimeter and millimeter) they might use a meter tape to answer such questions as the following:

How many meters long is the room?

The window pane is how many centimeters wide?

What are the centimeter dimensions of the face plate on the light switch?

Unsharpened pencil lead is how many millimeters thick?

For some initial measurement activities both the object to be measured and the unit to be used should be selected by the teacher. Measurements should be reported to the nearest <u>whole</u> unit.

After some time has been spent with these measurement activities, activities in estimating lengths of various objects should be provided. The objects to be measured and the units to be used should be varied. The emphasis should be "estimate, then check by measuring." Care should be taken to avoid precise measurements in checking. The goal is not great skill in estimating and measuring; the goal is to think metric—internalize the units.

Convenient Referents

Students should look for convenient models for some of the commonly used units. It might be, for example, that the width of the nail on their little finger is about 1 cm, the distance across the back of their hand is 1 dm, or the top of their hipbone is about 1 m above floor level. Objects commonly carried in pocket or purse may provide convenient models.

The purpose of such an approach is to promote thinking metric on the part of students who have grown up learning to think in and to use the English system and who must now, in a short period of time, change and begin to think metric. Precise measurements and accurate estimates are not especially important. What is important is that the students quickly build a set of referents which will enable them to make judgments about measurements of other objects as well as to internalize the metric system. This approach should be applied to the teaching of area, volume, and mass as well.

Little Conversion

Conversions between the metric system and the customary system should be avoided while learning the metric system. Conversions between systems can be made, when necessary, by simply consulting a table of equivalents readily available and doing the necessary multiplication or division. This is something which needs little instruction. It is appropriate, however, to make a few rough basic

comparisons such as between the meter and the yard, the liter and the quart, and so on.

Conversions within the metric system, on the other hand, are quite a different matter. Converting from one metric unit to another is easily done by simply multiplying or dividing by a power of 10; a very simple task compared to converting in the customary system. Perhaps because it is so easy there is a tendency for teachers to overemphasize this activity. Some practice with conversions in the metric system is appropriate but practicing mechanical shortcuts is of questionable value. Instead, it seems more appropriate and beneficial to reason from the basic relationships between the units. Consider the following:

a. 750 grams = _____ kilogram(s)

The reasoning could be:

We have 750 grams and it takes 1000 grams to make a kilogram, so we have only 0.750 kilogram.

b. How many milliliters does a 3-liter container hold?

The reasoning might be:

The container holds 3 liters, and since 1 liter is 1000 milliliters the container holds 3000 milliliters.

Use of this Guide

This guide is addressed to the teacher. Its aim is to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding the presentation of the material in the classroom. A variety of activities is given and directions for some of these are addressed to the student. Nevertheless, it is not intended to be a workbook for students, nor is it intended that the activities given are sufficient or comprehensive. The attempt has been to provide examples of suitable activities designed to help the students think metric.

Several types of activities are suggested in each section. Each of these types makes a unique contribution to the learning process. It is appropriate, then, that some of each type should be provided for the student as each section is developed.

I. Measure

e.g., p. 14, exercise 1

II. Estimate and Measure

e.g., p. 26, exercise 2

III. Reasonable ("ball park") Estimates

The diameter of an aspirin tablet is _____.

(a) 3 m (b) 1 cm (c) 15 mm

IV. Metric Conversion Drill

1450 g = _____ kg

V. Applications

This guide is addressed to personal and public service occupational programs including Child Care; Industrial Sewing; Food Management, Production and Services; Interior Decorating; Cosmetology; and Environmental Control. Some of

the activities and exercises included are of a general nature and some are related to specific occupations. It is intended that the teacher will select from the items suggested those which are appropriate to the group of students involved and it is expected that those suggested will stimulate the creation of additional or more appropriate items by the teacher.

It must be emphasized again that the actual measurements of some of the objects given are not important. What is important is that the students have the opportunity to actively estimate and measure many objects with which they have frequent contact; that they be encouraged to "think metric."

The System

The metric system had its beginning in the latter part of the 18th century when a group of French scientists, commissioned by their government, developed a system of measurement units. The system was officially adopted by the French government in 1795, and in 1840 its use was made mandatory by the government. Over the years most of the countries of the world, including the United States, have adopted it. In 1866 the U. S. Congress passed an act making it legal but not mandatory to use the metric system in the United States. The Eleventh General Conference on Weights and Measures, meeting in 1960, adopted the International System of Units (SI)—the universally recognized metric system today. In December, 1975, HR 8674 was signed into law by President Ford, a bill that provides for the establishment of a 17-member metric board that will coordinate voluntary conversion to the SI in the U. S.

The SI is a modernized metric system of measurement with features which make it superior to the U. S. customary system and to other metric systems. One feature is that the base of the system is <u>absolute</u>; that is, force is not defined by action of gravity. An absolute system makes for simplicity of calculation. In SI units, a force of one newton gives a mass of one kilogram an acceleration of one meter per second per second. By contrast, in the European system, a force of one kilogram-force accelerates a mass of one kilogram 9.806 650 meters per second per second, and in the U. S. customary system, one pound-force accelerates a mass of one slug 32.174 feet per second per second. Another feature is <u>coherence</u>. In a coherent system any derived unit is related to any other, or to the base units, without the use of conversion factors. A third feature is that only <u>one unit</u> is used for each physical quantity. By contrast, the customary system has nine commonly used units for area, 25 units

for energy, and 26 units for length.

The SI consists of seven base units, two supplementary units, and derived units, some of which have been given special names.

Base Units

Unit	Quantity	SI Symbol
meter	length	m
kilogram	mass	kg
kelvin	temperature	K
ampere	electric current	A
mole	molecular substance	mol
second	time	s
candela	light intensity	cd

The derived units are determined by multiplying or dividing base units, without using numerical factors other than one. Some of these are shown below. For a more complete listing of these units see Appendix A or a source from Appendix C.

Some Derived Units Without Special Names

Unit	Quantity	Formula
square meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
kilogram per cubic meter	density	kg/m^3

Some Derived Units With Special Names

Unit	Quantity	SI Symbol	Formula
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
volt	electric potential	V	W/A
hertz	frequency	Hz	1/s or s^{-1}
ohm	electric resistance	Ω	V/A
farad	electric capacitance	F	C/V

Multiples and submultiples of these units are expressed by means of certain prefixes.* Some of the prefixes are:

Prefix	Meaning	SI Symbol
mega	1 000 000	M
kilo	1 000	k
hecto	100	h
deka	10	da
deci	0.1	d
centi	0.01	c
milli	0.001	m
micro	0.000 001	μ

*For a more complete listing of the prefixes, see Appendix A.

The prefixes have decimal meanings, i.e., each is a power of ten, and conversions among the units is facilitated by a knowledge of our numeration system.

Examples

1 hectogram	=	100 grams	(1 hg = 100 g)
1 centimeter	=	0.01 meter	(1 cm = 0.01 m)
1000 grams	=	1 kilogram	(1000 g = 1 kg)
1 meter	=	10 decimeters	(1 m = 10 dm)
1 deciliter	=	0.1 liter	(1 dL = 0.1 L)*

Not all the prefixes will be used in actual practice. Note that the SI symbol for a unit is used for both the singular and plural forms. Other established conventions for spelling, usage, etc., include:

1. Symbols for unit names are written in lower case unless they are derived from proper names. Most SI symbols for unit names are single letters (for some exceptions see Appendix A).

   RIGHT: Contents 454 g
   WRONG: Contents 454 GM

2. Periods are not used after the symbols or prefixes unless a sentence ends with such.

   RIGHT: The pencil is 16 cm long.
   WRONG: The pencil is 16 cm. long.

3. A zero digit is used in the units place when naming a number less than 1.

   RIGHT: The distance to the next road is 0.8 km.
   WRONG: The distance to the next road is .8 km.

---

*The symbol for liter as prescribed in the SI is "ℓ". In December, 1976, however, the National Bureau of Standards stated that the capital letter "L" will be used instead in the U. S. This symbol has several advantages over the "ℓ" and has been urged for adoption in the SI.

4. Numerals containing more than four digits should be separated into groups of three digits in order to facilitate reading. No commas should be used in the spaces between groups of digits.

RIGHT: The distance from the earth to the moon is about 385 000 km.
WRONG: The distance from the earth to the moon is about 385,000 km.

RIGHT: A microgram is equal to 0.000 001 g.
WRONG: A microgram is equal to 0.000001 g.

5. Prefixes are not to be used without a unit.

RIGHT: The weight lifted was 186 kilograms.
WRONG: The weight lifted was 186 kilos.

Additional information and discussion of the metric system may be found in a number of current sources (Appendix C).

Length

In the personal and public service occupations the metric system has not been used extensively in the measurement of length. This means that as the country shifts to the metric system there will be a great impact on personal and public service personnel but it also means that there is now a great opportunity--the opportunity to develop nationwide and worldwide standards for a variety of items. Suitable standards and measurement units are being discussed in many different areas. There are many decisions to be made about standards for items related to the personal and public service occupations. Home economists, consumer advocates and others are presently serving on committees studying some of these areas. A few of the questions being considered are:

What metric units will be used in recipes?

What sizes of utensils will be manufactured?

What should be the dimensions of a shirt?

How will shoes be sized?

What carpeting widths should be manufactured?

What will be the dimensions of a wall oven?

What size containers will margarine be packaged in?

Many of these questions relate to length measurement. Cooking and baking utensils may soon be marked for size in centimeters. Initially, perhaps, there will only be a "soft conversion" and the metric sizes will be in fractions such as 22.5 centimeters. As manufacturers are able to make "hard conversion" the new dimensions may instead be 20 or 25 centimeters.

There is some indication that clothing sizes will be expressed in centimeters. A man's shirt presently sized 15½ may become size 39 (39 cm). Shoes

may be sized according to the length and width of the foot. The size 280/90 would fit a foot 280 millimeters long and 90 millimeters wide. Some metric units are presently marked on pattern instruction sheets, pattern books and pattern pieces. The pattern industry will begin to supply all of the needed information in metric units rather than the customary units. Fabrics may be sold by the meter and the width may be expressed in centimeters. Fabric widths may be changed slightly so they can be expressed in whole numbers. Carpeting, floor coverings, and wall coverings may be sold in widths which are multiples of a meter.

In the metric system (SI) the basic unit of length is the meter--probably the most familiar of the metric units. The meter is a little longer than the yard. Other metric units of length which are frequently used are:

kilometer--about 0.6 mile (or 7 city blocks) — 1 km = 1000 m

decimeter--the length of segment AB — 1 cm = 0.1 m

A ——— B

centimeter--the length of segment CD — 1 cm = 0.01 m

C D

millimeter--the length of the segment to the right — 1 mm = 0.001 m

Suggested Activities*

1. Find several objects which have approximately the measurements in the chart below. Try to find things which you can easily remember or that you are frequently near. Include body measurements such as palm width, length of a finger, distance from hip to floor, etc.

1 m	1 dm	1 cm	1 mm

*The activities suggested in this book are meant to include several areas in the public and personal service occupations. The teacher may select from these activities those most appropriate to the subject and students being taught.

2. Use the objects listed below and others from your school or home to practice linear measurement. The main objective is to develop a better "feel" for metric units of length, and therefore rough estimates and measures are adequate. Some objects you are near frequently; the measures of these and a few others (table height, for example) you will want to remember. More than one dimension of some objects may be estimated. Check your estimates by measuring.

Object	Estimated Length	Measured Length
Pane of glass		
Concrete block		
Note pad		
Checkbook		
Floor tile		
Straight pin		
Dressmaker's tracing wheel		
Height of base cabinets		
Kitchen sink		
Spatula		
Rolling pin		
Slice of bread		
Comb		
Hair roller		
Nail file		
New pencil		
Table		
_____		
_____		
_____		

The purpose in all these activities is to help foster "thinking metric." Accuracy in estimating is not crucial. Discourage students from measuring too precisely here.

3. Draw a line segment that has length

(a) 1 dm (b) 5 cm (c) 3 mm (d) 15 cm (e) 20 cm

Check by measuring. Try again with some other lengths until you are satisfied with your estimating skill.

A feel for metric units is important. Practice with estimating helps to think metric. Exercises such as the following also help. They will be of little value, however, if students do them by conversion. Instead, they should be done by just considering what is a reasonable answer. The measures given in exercises 4 and 5 and in similar exercises later in the unit are not important. Students may not know these measures nor do they need to in order to answer the questions. They should be able to rule out the inappropriate units or measures just by a general familiarity with the objects involved.

4. Supply the appropriate unit to make the sentence reasonable. Choose from mm, cm, dm, m, or km.

   a. The length of a baking sheet is 60 _____.

   b. A French seam when finished should be about 5 _____ wide.

   c. To stitch a seam one should begin about 1 _____ from the end of the seam.

   d. The length of a paring knife might be 1.5 _____.

   e. The thickness of a dime is 1 _____.

   f. The distance from Chicago to St. Louis is about 480 _____.

   g. The width of a door might be about 0.8 _____.

   h. The width of a living room might be 42 _____.

   i. The length of a permanent rod is about 90 _____.

   j. Grade AA eggs have an air cell of 0.3 _____ or less.

   k. Feathervale, the lightest and finest corduroy, has 7 to 8 wales per _____.

5. Choose the best answer from those provided.

   a. The diameter of an aspirin tablet is _____.

      (1) 3 mm (2) 1 cm (3) 15 mm

b. The distance from New York to Los Angeles is about _____.

(1) 5000 m (2) 5000 km (3) 3000 km

c. The height of a bedroom window might be _____.

(1) 56 dm (2) 56 cm (3) 12 dm

d. Dressmaker's scissors are _____ or less in total length whereas shears are more than _____ in total length.

(1) 1 dm (2) 20 cm (3) 15 cm

e. The cookie recipe called for the dough to be rolled into balls _____ in diameter and dropped onto the cookie sheet.

(1) 3 mm (2) 2.5 cm (3) 30 cm

Converting between metric measures is a needed skill. It is much easier than in the customary system (yards to inches, etc.), so there is some danger of overemphasizing this activity or of emphasizing mechanical procedures. Conversions among mm, cm, dm, m and km are all that is required. Knowledge of a few basic relations of a decimal nature is sufficient for this.

10 mm = 1 cm	10 dm = 1 m	1000 mm = 1 m
10 cm = 1 dm	1000 m = 1 km	100 cm = 1 m

For example, since 1 dm = 10 cm

$$8.6 \text{ dm} = (8.6 \times 10) \text{ cm} = 86 \text{ cm}.$$

Likewise, since 1 dm = 100 mm

$$8.6 \text{ dm} = (8.6 \times 100) \text{ mm} = 860 \text{ mm}.$$

6. Complete the following:

a. _____ mm = 56 dm

b. 56 dm = _____ m

c. _____ m = 3.2 km

d. 28 cm = _____ mm

e. 28 cm = _____ m

f. 8000 m = _____ km

g. 6 m 3 dm 5 cm = _____ m = _____ cm

h. 5 cm 8 mm = _____ cm = _____ m

For "fun":

i. _____ in. = 3 yd. 2 ft. 7 in.

j. 2 yd. 1 ft. 5 in. = _____ yd. = _____ in.

7. If 10 meters of seam binding costs $1.10, what is the cost of 25 meters of this binding?

Area

Area measurement using metric units seldom occurs at present in the personal and public service occupations, but will occur with gradually increasing frequency as floor coverings, rolled goods, piece goods, and similar materials are made available from manufacturers. The initial activities here as elsewhere are designed to help think metric.

Suggested Activities

A unit of area convenient in many instances is the square centimeter: . "Square centimeter" is expressed with the symbol cm^2.

1. Make a model of a square centimeter from paper.
2. Use your model to help estimate the area of these regions.

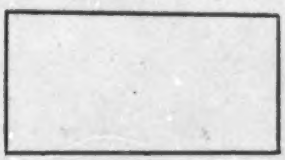


Figure 1

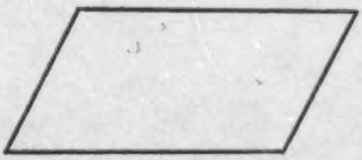


Figure 2

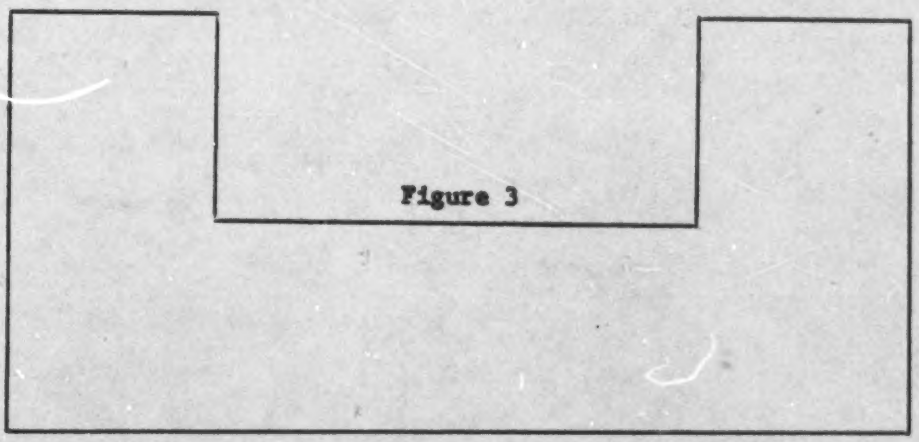


Figure 3

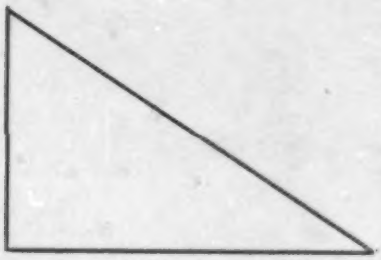


Figure 4

Figure 5

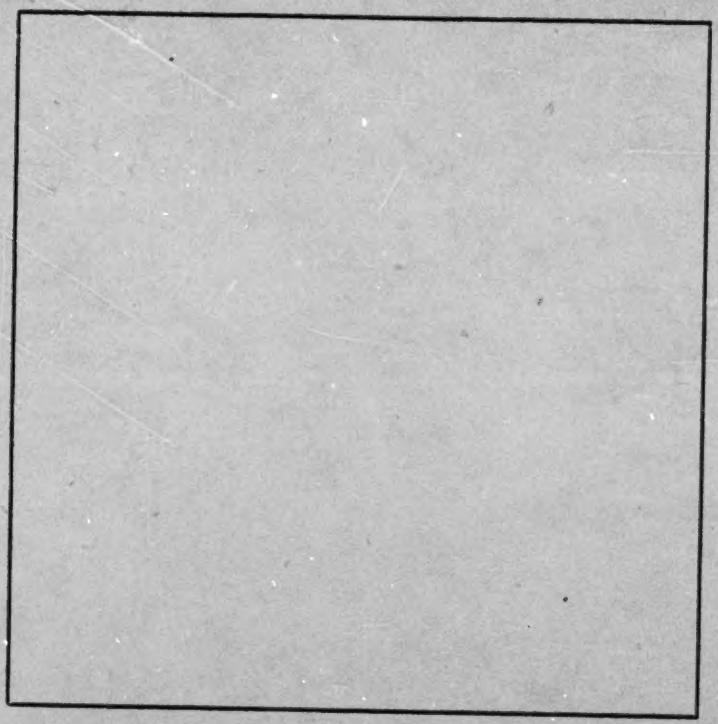
Region	Estimated Area
1	_____
2	_____
3	_____
4	_____
5	_____

The area of a rectangular region is, of course, computed by the formula $A = lw$. For example, a rectangle 2 m by 3 m has an area of 6 square meters (6 m^2); a rectangle 2 cm by 3 cm has an area of 6 cm^2; a large room 8 m by 10.5 m has an area of 84 m^2. Formulas for the area of a triangle and circle are $A = \frac{1}{2}bh$ and $A = \pi r^2$.

3. Check your estimates in number 2 by using your ruler to measure any segments needed to calculate the area.

Region	Calculated Area
1	_____
2	_____
3	_____
4	_____
5	_____

Another convenient unit of area is the square decimeter (dm^2).



4. Make a model of this square unit from heavy paper. Use your model as an aid to estimate the area of several objects. Check your estimate by measuring and calculating. Some objects are suggested; include others from your classroom, home, or place of work.

Object	Estimated Area	Calculated Area
File cabinet		
Dish washer		
Detergent box		
Baking sheet		
Desk top		
Book cover		
Window pane		
Floor tile		

5. A square meter is a rather large unit of area. What objects can you find in your classroom that have an area of approximately:

a. 2 m^2 _____ _____

b. 4 m^2 _____ _____

c. 0.5 m^2 _____ _____

6. Supply the appropriate unit to make the sentence reasonable. Choose from cm^2, dm^2, or m^2.

a. The floor area of a house might be 150 _____.

b. This sheet of paper has an area of about 616 _____.

c. The floor of the classroom is about 38.5 _____ in area.

d. The hamburger is about 75 _____ in area.

e. The lamp table has a top with an area of 27 _____.

f. The area of a postage stamp is about 3 _____.

g. Four _____ of material were used to make drapes for a window.

7. Calculate the area of these rectangular regions:

a. 4 m x 5 m

b. 6 cm x 8 cm

c. 3.6 m x 8 m

d. 27.5 m x 7.6 m

e. 350 m x 500 m

f. 285 m x 312 m

8. Using the given dimensions for a rectangular region find the area in cm^2.

a. 4 m x 18.5 cm

b. 2 m x 3 m

c. 2.5 m x 4.2 cm

d. 22 cm x 28 cm

Find the area in m^2.

e. 420 cm x 5 m

f. 118 cm x 25 cm

g. 65 cm x 6.25 m

h. 0.5 m x 120 m

Sometimes a larger unit of area is convenient. The SI permits the use of hectare (ha) as a unit for measuring large land or water areas. 1 hectare = 10 000 m^2, so a plot 200 m by 300 m has an area of 6 ha.

9. A football field is about 49 m by 100 m (including one end zone). It has an area of about _____ m^2. Two football fields have an area of about _____ m^2. One hectare is 10 000 m^2, so two football fields have a combined area of approximately 1 hectare.

10. Find the area in hectares.

    a. 60 m x 75 m

    b. 150 000 m^2

    c. 100 m x 100 m

    d. 20 m x 1 km

A square 100 cm on each side is the same size as a square 1 m on each side. Such a square would contain 100 rows of 100 cm^2 each. Consequently 1 m^2 = 10 000 cm^2.

11. Complete the following.

    a. 3 m^2 = _____ cm^2

    b. _____ m^2 = 5000 cm^2

    c. 5 dm^2 = _____ cm^2

    d. 250 cm^2 = _____ dm^2

    e. 40 000 cm^2 = _____ m^2

12. A table top 120 cm by 300 cm has an area of 36 000 cm^2 or _____ m^2.

13. There are five shelves in a metal storage cabinet each 6 dm wide and 9 dm long. The total storage area of these shelves is 270 dm^2 or _____ m^2.

14. How many square meters of material would be needed to make drapes for a window 80 cm x 1.4 m?

15. Find the area of a floor in square yards which measures 7 ft. 7 in. by 5 ft. 6 in.

16. Find the area of a floor in square meters if the floor measures 231 cm by 167 cm.

17. A food range having an area of _____ is adequate to serve about 14 000 meals per week in a student union.

a. 335 dm^2 b. 2000 mm^2 c. 200 m^2

18. The city of Philadelphia won the America's Bicentennial Bake-off with a record _____ cake.

a. 141 250 cm^2 b. 141.25 dm^2 c. 1366 m^2

19. A meat table measures 75 cm by 180 cm. The area is _____ cm^2 or _____ m^2.

Volume

The concept of volume arises frequently in the personal and public service occupations. In the customary system many different units are used--bushel, peck, quart, gallon, ounce, teaspoon, tablespoon, cup--some for dry measure, some for liquid measure. Cubic units such as the cubic inch and cubic foot are also used to express volume. In the metric system, however, there are only two ways to express volume: in cubic units and in liters.

Cubic Measure

The cubic meter (m^3), cubic decimeter (dm^3), and cubic centimeter (cm^3) will be the commonly used cubic units. It is common to see "cc" used to represent "cubic centimeter." This has been the case with medicines for some time and it is now seen on labels for cosmetic preparations and other solutions. The proper SI symbol, however, is cm^3.

The cubic meter will be used to describe the volume of rooms or buildings. It may be used for the capacity of refrigerators or freezers. The cubic decimeter may not be used often but it plays an important role in relationships among other metric units which will be discussed later.

The volume of a rectangular solid is given by the formula $V = lwh$. The volume of a cylinder is $V = \pi r^2 h$. In these cases and in others where the volume can be computed by formula, cubic units will be used to express the volume. In many other cases the liter (discussed later) will be used.

Suggested Activities

1. a. Make a model of a cubic centimeter and cubic decimeter out of heavy paper. A suggested diagram is given in Appendix B. (Metal or wood is suitable, also.)

b. Make a model of a cubic meter using meter sticks or similar material for edges.

c. Challenge. Make a model of a cubic millimeter.

2. Estimate the volume of several objects in the room by thinking of cubic units--m^3, dm^3, or cm^3. Check your estimates by measuring with the cubic unit or a tape. Some objects are suggested; include others from your room, home, or place of work.

Object	Estimated Volume	Measured Volume
Deep fryer		
Detergent box		
Dehumidifier		
Loaf pan		
Griddle brick		
Proof box		
Pin box		
Oven		
Sink compartment		
Cabinet drawer		
Teacher's desk		
Chalkboard eraser		
File cabinet		
_____		
_____		
_____		

3. Supply the appropriate unit to make the sentence reasonable. Choose from mm^3, cm^3, dm^3, or m^3.

a. The volume of an electric toaster is about 12 000 _____.

b. A plastic scrub bucket would hold about 10 _____ of water.

c. A walk-in freezer might have a volume of 20 _____.

d. A family-sized refrigerator has a capacity of 500 _____.

4. Remembering that it would take 1000 cm^3 blocks to occupy the space of one dm^3 and that 1000 dm^3 blocks fill one m^3, complete the following to make true sentences.

a. 2 m^3 = _____ dm^3

b. 500 cm^3 = _____ dm^3

c. 4000 cm^3 = _____ m^3

d. 4000 dm^3 = _____ m^3

e. 0.42 dm^3 = _____ cm^3

f. 1.491 m^3 = _____ dm^3

g. 0.1024 dm^3 = _____ cm^3

h. 186 321 cm^3 = _____ m^3

i. 144 dm^3 = _____ cm^3

j. 144 dm^3 = _____ m^3

5. A box that is 1 dm wide, 2 dm long and 1.5 dm high has a volume of _____.

a. 4.5 dm^3 b. 3000 cm^3 c. 4.5 cm^3

6. The sink at a vegetable preparation table is 50 cm x 50 cm x 30 cm. What is the volume of the sink?

7. The volume of the case for a beauty kit is _____ dm^3 or _____ cm^3.

Liter Measure

The liter is not one of the basic SI units but it is a convenient unit and is used frequently enough that it has been accepted by the SI. The liter is just a little larger than a quart and will probably be used for small to moderately sized amounts. For large amounts it seems likely that the cubic meter will be the appropriate unit. So there are two alternatives for describing measures of volume or capacity—cubic measure and liter measure. There is no set rule stipulating which of the two measures should be used in a given situation. It seems to be simply a matter of custom and convenience.

One of the nice features of the metric system is the ease with which one may change from one unit of measure to another. This pertains to the interchange

between cubic measure and liter measure as well. A liter container holds exactly the same amount as a cube one decimeter (10 cm) on each edge; that is, 1 L = 1 dm^3. Consequently, a 10-liter pail has a volume of 10 cubic decimeters, a 2-liter milk carton has a volume of two cubic decimeters, and a 1000-liter tank has a volume of 1 cubic meter.

Since a cube 10 centimeters on each edge contains 1000 cubic centimeters, each of these cubes is 0.001 of a cubic decimeter and hence is 0.001 of a liter. That is, one cubic centimeter equals one milliliter. In some areas, principally in medicine, the cubic centimeter and the milliliter are constantly used interchangeably.

There are some useful approximations between customary household measures of volume and metric measures of volume. One teaspoon is approximately equal to five milliliters, one tablespoon is approximately equal to fifteen milliliters, and the customary measuring cup used in cooking holds about 240 milliliters. There has been a great deal of discussion to the effect that a "metric cup" is the equivalent of 250 milliliters. Actually, there is no valid reason why the term metric cup should be used at all. It is true that for cooking purposes and other uses we will find it convenient to have a container with a capacity of 250 milliliters, but there is no reason to distinguish this container by referring to it as a metric cup.

The Metal Cookware Manufacturers Association (MCMA) has completed a Metric Guide for Metal Cookware and Bakeware to aid the industry as it converts to the metric system. Among the recommendations are:

> The capacities of liquid measures will be one liter, 500 mL, and 250 mL.
>
> Dry measures will have capacities of 500, 250, 125, and 50 mL.
>
> Small measures will have capacities of 25, 15, 5, 2, and 1 mL.

The words cup and spoon will not appear in conjunction with metric measures.

The American Home Economics Association recommends that volume measurements for both dry and solid ingredients be used in recipes for the homemaker. Measurements for ingredients such as meat and butter will no doubt be by mass (kg or g).

A few manufacturers are now making sets of metric measures for the kitchen in a variety of combinations. Some of these are in the familiar plastic or stainless steel pan shape; others are in spoon shape. Typical sets may have capacities of 250, 125, 80, 60, 30, 15, 7.5, 5, 2.5, 1.2 and 0.6 mL. There are other containers of 250 mL or 500 mL capacity with graduations marked on them ranging from 250 or 500 down to 50 mL. Some utensils also have the customary graduations as well.

As with other metric units, it is important to develop a feel for the metric units of liter and milliliter. Activities such as the following may help with this.

Suggested Activities

1. Estimate the capacity of each of these. Check your estimate by using water and a graduated cylinder to measure the capacities of small containers. Select some other containers familiar to you and learn their capacities.

Object	Estimated Size	Measured Size
Pop can		
Thimble		
Soup spoon		
Dinner glass		
Catsup bottle		
Steamer pan		
No. 10 can		
Ladle		
Salad mold		
Pitcher		
Barbicide jar		
_____		
_____		

2. Supply the appropriate unit to make the sentence reasonable. Choose from liter (L) or milliliter (mL).

   a. 30 _____ of Pepto-Bismol may be taken for upset stomach.

   b. Chocolate milk may be purchased in 2 _____ containers.

   c. Mary poured 100 _____ of syrup on her hotcakes.

   d. A 1 _____ saucepan is suitable for warming a package of frozen corn.

   e. The jar contains 125 _____ of French dressing.

   f. Each sewing machine worker was provided with a 100 _____ oil can to be used in servicing the machine.

   g. The small bottles of hair conditioner contained 360 _____ of conditioner.

   h. With each restaurant order of spaghetti, 25 _____ of parmesan cheese was provided.

3. Choose the best answer from those provided.

   a. A No. 303 can holds about _____.

      (1) 500 mL (2) 2 L (3) 10 L

   b. A two-year-old child might drink _____ milk in a day.

      (1) 1000 mm^3 (2) 750 mL (3) 10 L

   c. A beef noodle casserole for 100 servings requires _____ of finely chopped onions.

      (1) 100 mL (2) 250 mL (3) 3.75 L

   d. A custard cup holds _____.

      (1) 1 L (2) 20 mL (3) 90 mL

   e. A large mixing bowl contains _____.

      (1) 1500 mL (2) 40 L (3) 8 L

   f. For mosquito larvae control, No. 2 grade fuel oil may be applied to surface water at the rate of _____ per hectare of water.

      (1) 20 to 50 mL (2) 1 to 4 L (3) 20 to 50 L

The liter and milliliter are probably the only two liter measures that will be used in practice. Conversions between liter and milliliter are done simply by remembering that

$$1000 \text{ mL} = 1 \text{ L}$$

$$1 \text{ mL} = 0.001 \text{ L}$$

For example, 258 mL = (258 x 0.001) L = 0.258 L.

4. Complete the following.

   a. 1 liter = _____ mL

   b. 2000 mL = _____ L

   c. 20 000 mL = _____ L

   d. 0.25 L = _____ mL

   e. A 10-liter bucket holds _____ mL.

   f. A box which measures 10 cm on each edge has a volume of 1 _____.

   g. At 4 ^{o}C one liter of distilled water weighs 1 kilogram. At that temperature _____ mL would weigh 1 gram.

   h. Fractional parts of a liter are expressed in decimal form. Thus 2½ liters would be written as 2.5 L which equals _____ mL.

5. It would take _____ mL of Lysol to make one liter of 10% Lysol solution.

6. A 2-liter container of lemonade will be adequate for eight _____ mL servings.

7. Make the following conversions between cubic units and liter measures.

   a. 18 cm^3 = _____ mL

   b. 5 dm^3 = _____ L

   c. _____ cm^3 = 250 mL

   d. 18 L = _____ dm^3

   e. 1.5 L = _____ m^3

   f. 0.3 dm^3 = _____ mL

   g. A box 2 cm by 3.5 cm by 10 cm has a volume = _____ = _____ mL.

Mass

The measurement of mass will be an important activity in many of the personal and public service occupations. A few metric units of mass are already used to some extent. Recipes of European origin are usually formulated using the gram as the basic unit for amounts of ingredients. Some canned goods and other products are now on the shelves marked in both customary and metric units. Nutritive amounts of protein, carbohydrates, fats, etc., shown on labels of food products and elsewhere are listed in grams. Vitamin content is given in milligrams.

The terms mass and weight and their use have recently had considerable discussion. Mass is a quantity with an SI base unit and force is a quantity with an SI derived unit, but the term weight does not appear in SI. In science and engineering, however, the term weight has been used, but a distinction between mass and weight has been carefully maintained. Currently, practices are being implemented (see Guidelines for Writers of SI Metric Standards, Appendix C) which will mean that the term weight will no longer be used in science and other technical fields. Instead, the term force of gravity will be used. In general everyday use, including the personal and public service occupations, no harm will occur by using the terms weight and mass synonymously.

Some abbreviations for metric units are in current use which do not conform to SI style practices. It is common to see the symbol gm, the abbreviation GM., and other expressions for gram. The symbol g, however, is the proper SI symbol for gram. "Kilos" is sometimes used in reference to the mass of an object, particularly in athletic weight lifting events. This incorrect and misleading usage should be avoided.

In the personal and public service occupations the most commonly used units of mass will be the kilogram, gram, and milligram. The kilogram is about 2.2 pounds—a little heavier than a box of American processed cheese. The gram, only 0.001 of a kilogram, is the approximate mass of a paper clip, and the milligram is only 0.001 gram. The metric ton (1000 kg), in common use today, is not an SI unit and may be gradually discontinued.

Suggested Activities

1. Supply the appropriate unit to make the sentence reasonable. Choose from kilogram (kg), gram (g), or milligram (mg).
   a. The mass of a candy bar is 40 _____.
   b. A golf tee has a mass of 1 _____.
   c. 250 mL of butter contains 180 _____ of fat.
   d. A piece of paper this size ☐ has a mass of 1 _____.
   e. A glass (150 mL) of orange juice contains about 2 _____ of Vitamin C.
   f. A cast iron skillet has a mass of 2.5 _____.
   g. The average American consumes about 44 _____ of sugar per year or more than 120 grams per day.
   h. Egg sizes are determined by the mass per dozen. Large eggs are those that have a mass of 616-672 _____.

2. Choose the best answer from those provided.
   a. 1 kg of dried peaches will yield _____ when cooked.
      (1) 3 L (2) 1 L (3) 250 mL
   b. A small wooden rolling pin has a mass of about _____.
      (1) 500 mg (2) 460 g (3) 5.2 kg
   c. A packet of sugar for a cup of coffee or tea contains about _____ of sugar.
      (1) 4.5 kg (2) 4.5 g (3) 4.5 mg

3. Estimate the mass of each of the following. Check your estimates by means of a balance or scale. Some objects you are often near; the masses of these you will want to remember.

Object	Estimated Mass	Measured Mass
Billfold		
Pencil		
Textbook		
Rolling pin		
Frying pan		
Teaspoon		
Medium sized potato		
No. 10 can of beans		
Can of shortening		
Scissors		
Thimble		
Spool of thread		
Bottle of hair conditioner		
Tube of waving lotion conditioner		
_____		
_____		
_____		

Changing from one unit of mass to another in the metric system is easily done in the same way as with linear units. Knowing the meaning of each prefix is all that is required.

1 milligram = 0.001 gram

1 gram = 1000 milligrams

1 kilogram = 1000 grams

1 gram = 0.001 kilogram

4. Complete the following.

a. 750 g = _____ kg

b. 1450 g = _____ kg

c. 500 mg = _____ g

d. _____ g = 2.5 kg

e. 1450 kg = _____ g

f. 10 g = _____ mg

5. Approximately 85% of an apple is water. About how many grams of water are in an apple that has a mass of 105 grams?

6. How many 250 gram boxes of pins can be packaged from a carton containing 2 kilograms of pins?

Volume--Mass

One of the nice features built into the metric system is the relationship between volume and mass. For several reasons water has been used to establish this relationship: 1 dm^3 of cold water has a mass of 1 kg. (To be exact, the water should be distilled and at a temperature of 4 °Celsius.) Thus, 5 dm^3 of water has a mass of 5 kg. Furthermore, because the specific density of all other substances is related to water it is easy to find the mass of any substance if the volume of the substance is known. For example, the density of steel is 8 times that of water so 1 dm^3 of steel has a mass of 8 kg, 2 dm^3 of steel has a mass of 16 kg; alcohol is only 0.84 times as dense as water so 1 dm^3 of alcohol has a mass of 0.84 kg, 2 dm^3 of alcohol has a mass of 1.68 kg, etc.

Since 1 dm^3 = 1 liter, 1 liter of cold water has a mass of 1 kg. Also, since 1 dm^3 = 1000 cm^3 = 1 L, 0.001 dm^3 = 1 cm^3 = 1 mL. So 1 cm^3 of cold water has a mass of 1 gram and, likewise, 1 mL of cold water has a mass of 1 gram. For larger volumes observe that 1 m^3 = 1000 dm^3, so the mass of 1 m^3 of cold water is 1000 kg or 1 megagram.

Remember that this relationship is true for cold water--not for other substances. However, 1 dm^3 of most liquids would have a mass of approximately 1 kg.

Suggested Exercises

1. 6 mL of water has a mass of 6 _____.
2. 15 g of water would have a volume of _____ mL.
3. 250 g of water has a volume of _____.
4. _____ cm = 1 dm, so _____ cm^3 = 1 dm^3.
5. _____ dm = 1 m, so _____ dm^3 = 1 m^3.

6. 1 cm^3 of cold water has a _____ g mass.

7. 1 dm^3 of cold water has a mass of _____.

8. 1 m^3 of cold water has a mass of _____ kg.

9. The water in a tank 2 m by 1 m by 1.4 m has what mass?

10. In contrast to #9, try this one: The water in a tank 2 yds. by 1 yd. by 1.4 yds. weighs how much? (Hint: 1 $ft.^3$ of water weighs about 62.5 lb.)

It should be emphasized that the special volume-mass relationship in the metric system is restricted to volumes of cold water and their masses, not other substances. That is, a liter of cold water has a mass of 1 kg; a m^3 of cold water has a mass of 1000 kg; 1 milliliter of cold water has a mass of 1 gram.

To help with this understanding, the following experiment is suggested:

a. Take two containers, similarly constructed, each large enough to hold 1 liter.

b. Place the containers on opposite sides of a balance scale. Adjust the balance scale so that it balances properly. Fill one container with a liter of cold water and the other with a liter of popcorn. Are the scales now in balance? Does a liter of popcorn have a mass that is equal to, greater than, or less than a liter of cold water?

c. Repeat (b) above using a liter of sand or salt.

d. Repeat using a liter of buttermilk, molasses, vinegar, milk or some other liquid. In these cases are the masses approximately equal to that of water?

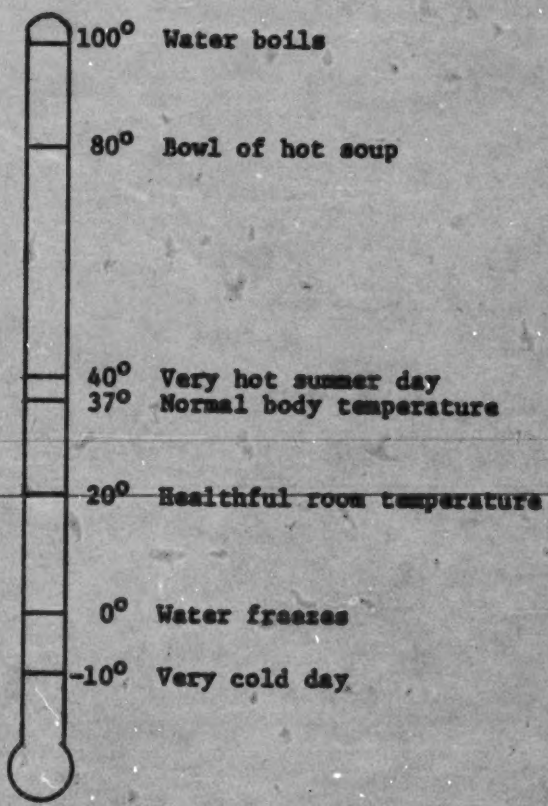
e. If the material is available, make a cube one decimeter on an edge out of cork or styrofoam. Compare the mass of this cube with that of a liter of water. (Caution: Be sure to compensate for the mass of the container holding the liter of water.)

Other Units

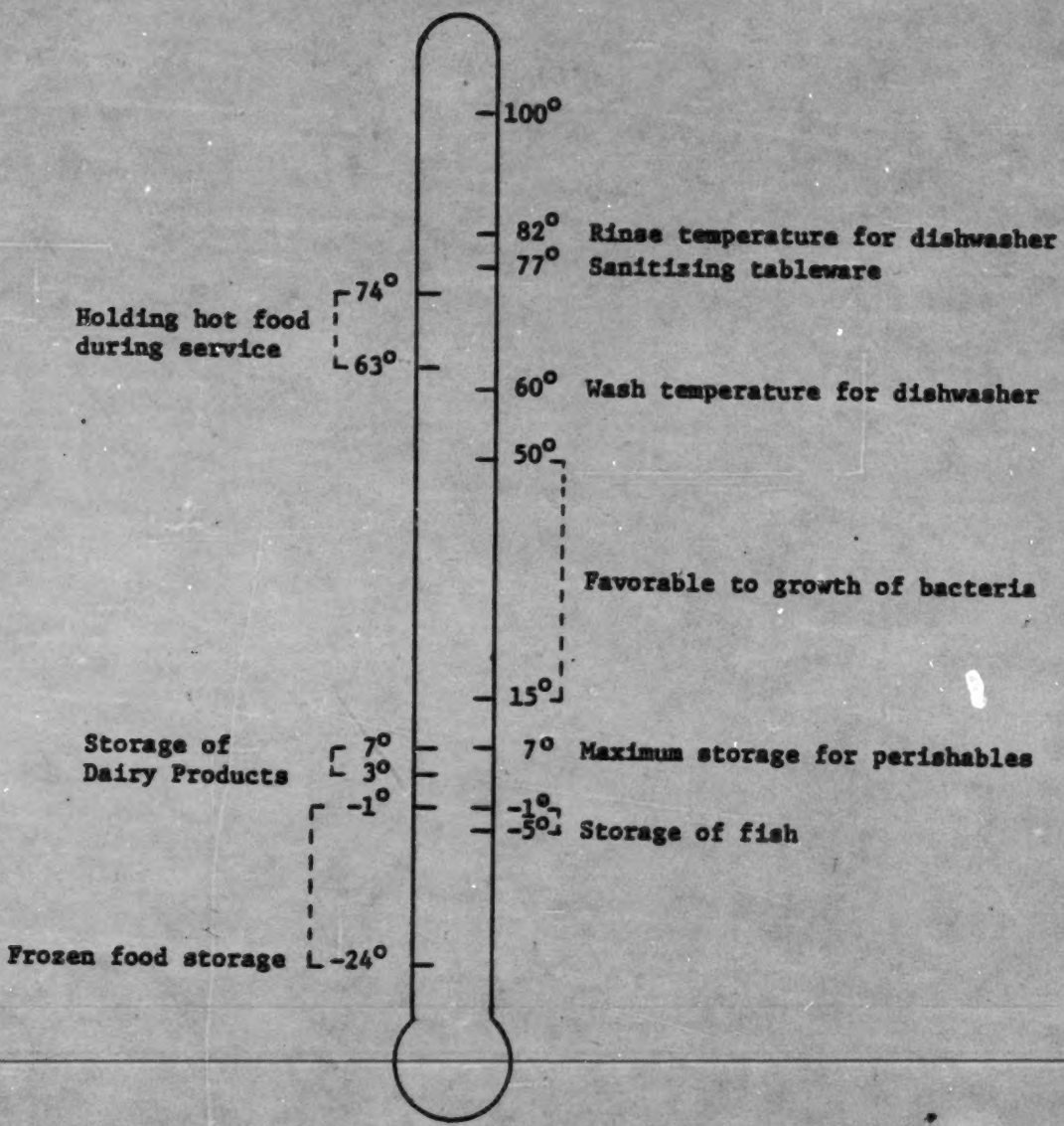
Several other metric units may be used to some extent in personal and public service occupations. A few of these are discussed here.

Temperature

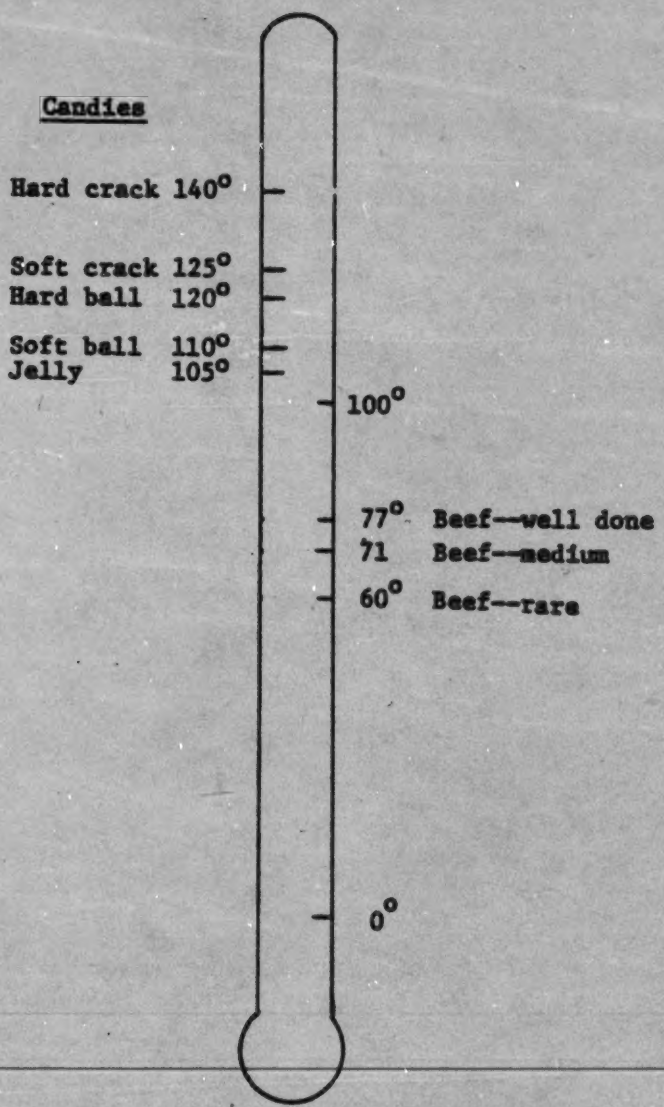
The basic SI unit of temperature, the kelvin, will be used primarily in the sciences. Temperatures for most non-scientific work will be reported in degrees Celsius (^{o}C). This is not a basic SI unit but it has been accepted for use with SI. The Celsius scale is named after the first man to use it and is identical to the centigrade scale which has been in use for many years. (The term centigrade, which is an inclination measurement of 0.01 of a right angle, should no longer be used for temperature measurements.) A few Celsius temperatures are pictured below.


100° Water boils
80° Bowl of hot soup
40° Very hot summer day
37° Normal body temperature
20° Healthful room temperature
0° Water freezes
-10° Very cold day

Food service personnel will be concerned with some of the following Celsius temperatures.



A few Celsius cooking temperatures are shown below.



The following illustrate some other uses of Celsius temperatures:

1. A new pan made of strong polycarbonate resin can withstand temperatures of from -46 °C to 100 °C;
2. To condition garments so that they are permanently pressed, the fabric is first treated with resins and partially set at a low temperature. After the garment is made, it is then "cured" in an oven for 4-18 minutes at a temperature of 150-170 °Celsius;
3. Autoclaving is a method of sterilizing which utilizes moist heat. No living thing can survive 10 minutes of direct exposure to saturated steam at 121 °C--the temperature reached at 105 kPa (15 psi);
4. A dry heat sterilizer is essentially an oven. Recommended temperature ranges from 160-180 °C for at least 1 hour and preferably longer.

Energy-Work

The metric unit of work, energy, and quantity of heat is the joule (J). Both work and energy are computed by multiplying force and distance. This product would be expressed in newton-meters (N·m). Torque is also the product of force and distance but is rotational rather than linear. To distinguish between the linear and rotational action of the force involved, the joule is used as the unit of work and the newton-meter is reserved as the unit of torque.

In the customary system there are several units of energy but those most commonly used are the calorie, the kilocalorie ("large" calorie), kilowatt hour, and British Thermal Unit (BTU). The calorie is used primarily as a measure of heat energy and the large calorie is used for food energy. In the metric system (SI), the joule or kilojoule will be used for all measures of energy. Since the joule is rather small, the kilojoule (kJ) and megajoule (MJ) are likaly to be used.

Listed below are the energy values for average servings of several different foods.

Food	Food energy
Salted peanuts, 50 mL	736 J
Coleslaw, 120 mL	343 J
Orange sherbet, 120 mL	540 J
Donut, cake type	523 J

Examples of energy consumption are:

Refrigerator per day	18 MJ
Range per meal	5.4 MJ
Oven per hour	1.8 MJ
Toaster per slice	18 kJ
Iron per hour	3.6 MJ
Water heater per day	43.2 MJ
Color TV per hour	1.18 MJ
100 watt bulb per hour	360 kJ
Hair dryer per hour	1180 kJ

The energy usage of the items above is currently measured in kilowatt hours. The kilowatt hour is a measure of work which is accepted in the SI but its use should not be extended beyond the present uses. Instead the megajoule should be used. Note that 1 kwh = 3.6 MJ.

Force

The SI unit of force is the newton (N). One newton is the force needed to give a mass of 1 kg an acceleration of 1 meter per second per second. In symbols this is expressed as: force (N) = mass (kg) x acceleration (m/s^2),

$$1\ N = 1\ kg \cdot m/s^2.$$

The newton is used for measuring the force needed to stretch a rubber band, to depress an automobile accelerator, to drag a box across the floor, to lift a baby, and for measuring the force of gravity. More specifically, the force needed to lift an apple is about 1 newton.

In the past, scientific and other technical use has differentiated between weight and mass. At the present time however, recommendations to the International Committee for Weights and Measures, and practices initiated by the American National Metric Council (ANMC) and the National Bureau of Standards (NBS) indicate that the term weight will be avoided in scientific and other technical fields. The term force of gravity will be used instead. In everyday activities the term weight may be used synonymously with mass.

The force of gravity on an object can be approximated if its mass is known. A kilogram mass exerts a downward force on the surface on which it rests. On earth the acceleration due to gravity is about 9.8 m/s^2, so the force exerted is 1 kg x 9.8 m/s^2 or 9.8 N. Roughly then, a 1 kg mass has a force of 10 N and the gravity force on a 250 gram hamburger is about 2.5 N.

Pressure-Stress

The SI unit for pressure is the pascal. It is the force of one newton per square meter (N/m^2). Thus, it is a measure similar to the conventional pound per square inch (psi). The pascal is a rather small unit of pressure. Imagine that 100 mL of water was poured evenly on a surface of one square meter. The layer of water would be very thin--only about 0.1 mm. The force exerted, one pascal, is quite small. Consequently, the kilopascal (kPa) will be frequently used. Some common pressures are

Auto Tire	200 kPa
City Water	280 kPa
Ten-speed Bike Tire	400 kPa
Auto Hydraulic Brake System	30 000 kPa (30 MPa)
Autoclave Sterilizer	105 kPa
Systolic Blood Pressure	16 kPa

Some other units of pressure which will be discontinued are pounds per square inch, centimeters of water, inches of mercury, millimeters of mercury, and the bar.

1 psi	= 6.9 kPa
1 cm of water	= 98 Pa
1 in. Hg	= 3.4 kPa
1 mm Hg	= 133 Pa
1 bar	= 100 kPa
1 millibar	= 100 Pa

Miscellaneous Exercises

1. Supply the appropriate unit.

   a. A pair of men's slacks has a waist size of 90 _____ and an inseam length of 80 _____.

   b. In stay-stitching, a bias edge uses matching thread and uses a stitch that is about 2.5 _____ long.

   c. A short stitch is one that has 7-9 stitches per _____.

   d. An orange with a 7.5 _____ diameter contains 48 mg of calcium.

   e. A food range having an area of 130 _____ is adequate to serve from 8500 - 10 000 meals per week in an employee cafeteria.

   f. The pans that fit into pan racks were 30 _____ by 50 _____ by 10 _____.

   g. At a restaurant a customer ordered a ham sandwich "to go." Inside the sack, along with the sandwich, were a 0.5 _____ packet of pepper and a 1.5 _____ packet of salt.

2. The area of a manicure table is _____ cm^2 or _____ m^2.

3. How many pin cushions can be made out of 0.5 meter of felt, 1 meter wide, if a 10-cm square piece is needed to make each side of the pin cushion?

4. A pillbox hat is to be made from a piece of cloth in the shape of a circle which has a diameter of 18 centimeters. If the circular piece is cut from a square piece of material 18 cm on a side, what is the area of the material "lost"?

5. On an automobile trip of 576 km, a traveler used 76 L of gas. The fuel consumption for this trip was _____ km/L.

6. It is essential that sewing machines be properly oiled in order thay they give long service with little trouble and expense. If a 4 liter container of oil is received and is put into 100 milliliter oil cans, how many such oil cans can be filled?

7. The USDA estimates that by the year 2000 the need for cereal grain in less developed countries will increase by approximately 650 000 000 megagrams, assuming no improvement in diets. Only 8% could be provided by developed countries. Of the increase, about how many megagrams can the developed countries provide?

8. Find the mass of a steam iron; a thimble; a needle.

9. Find the area of a swimming pool; baseball field; tennis court; carpet needed for a room.

10. Find the amount of paint needed for a wall.

11. The average American diet contains about 6 _____ of iron per 4200 joules and the average sedentary woman requires 18 _____ daily.

12. 15 _____ of granulated sugar contain 210 joules of energy.

13. Activities suggested by Elaine Parsons in the Illinois Teacher of Home Economics, November-December, 1975:

Measure several ingredients using standard measuring techniques:

½ cup sifted all-purpose flour + 1 Tbsp.

¼ tsp. baking soda

½ tsp. salt

¼ cup shortening (margarine or butter)

3 Tbsp. brown sugar (packed)

1/3 cup water

Now measure the following ingredients using the metric system:

70 g flour

2 g baking soda

1 g salt

40 g brown sugar

80 g water

60 g shortening

14. A 500 _____ steer bought "on the hoof" yields approximately 235 _____ of consumer-sized pieces of meat.

Other Information

1. Fuel value of nuts:

almonds (60 mL)	1780 J
2 cashews (25 g)	675 J
coconut (60 mL)	360 J
peanuts (15 mL)	210 J
pecans (15 mL)	218 J
walnuts (15 mL)	205 J

2. The following is a list of what a two-year-old child might eat in a day:

705 mL milk	juice of one orange
1 egg	80 mL applesauce
30 g meat	70 g oatmeal
30 mL potatoes	1 slice of bread
30 mL carrots	

3. Sizes of cans:

No. 300	420 mL
No. 303	500 mL
No. 2	625 mL
No. 2½	875 mL
No. 10	3 L

4. 3 medium apples weigh 0.5 kg

   1 dozen oranges will give 1 L of juice

   2 medium peaches weigh 500 g

   2 medium pears weigh 500 g

   2 kg of dried apples will yield 2.5 L when cooked

5. Recipe for Sunshine Shake (4 servings)

1 banana (cut up)
375 mL orange juice
125 mL crushed pineapple
15 mL lemon juice
125 mL water

Mix well in blender and chill or mash banana well, using pineapple juice instead of crushed pineapple, mixing well with an egg beater.

6. In the State of Maryland one of the agencies dealing with environmental planning reports air pollution and solid waste emissions in kg/day, kg/km^2, and metric tons per year.

7. Stitch length regulators on most European brand sewing machines are calibrated in metric units.

8. The melting point of butterfat is 180-207 °C.

9. Yeast grows best at a temperature of 25-30 °C. Bakeries keep dough at a temperature of 27-28 °C.

Appendix A

The Supplementary Units

Unit	Quantity	SI Symbol
radian	plane angle	rad
steradian	solid angles	sr

The Derived Units with Special Names

Unit	Quantity	SI Symbol	Definition
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
farad	electric capacitance	F	C/V
henry	inductance	H	V·s/A
hertz	frequency	Hz	1/s or s^{-1}
lumen	luminous flux	lm	cd·sr
lux	illuminance	lx	lm/m^2
ohm	electrical resistance	Ω	V/A
siemen	conductance	S	A/V
tesla	magnetic flux density	T	Wb/m^2
volt	electric potential	V	W/A
weber	magnetic flux	Wb	V·s

The Derived Units without Special Names

Unit	Quantity	SI Symbol
sqaure meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
radian per second	angular velocity	rad/s
meter per second squared	linear acceleration	m/s^2
radian per second squared	angular acceleration	rad/s^2
newton-meter	moment of force	N·m
kilogram per cubic meter	density	kg/m^3
joule per kelvin	entropy	J/K
watt per square meter	thermal flux density	W/m^2

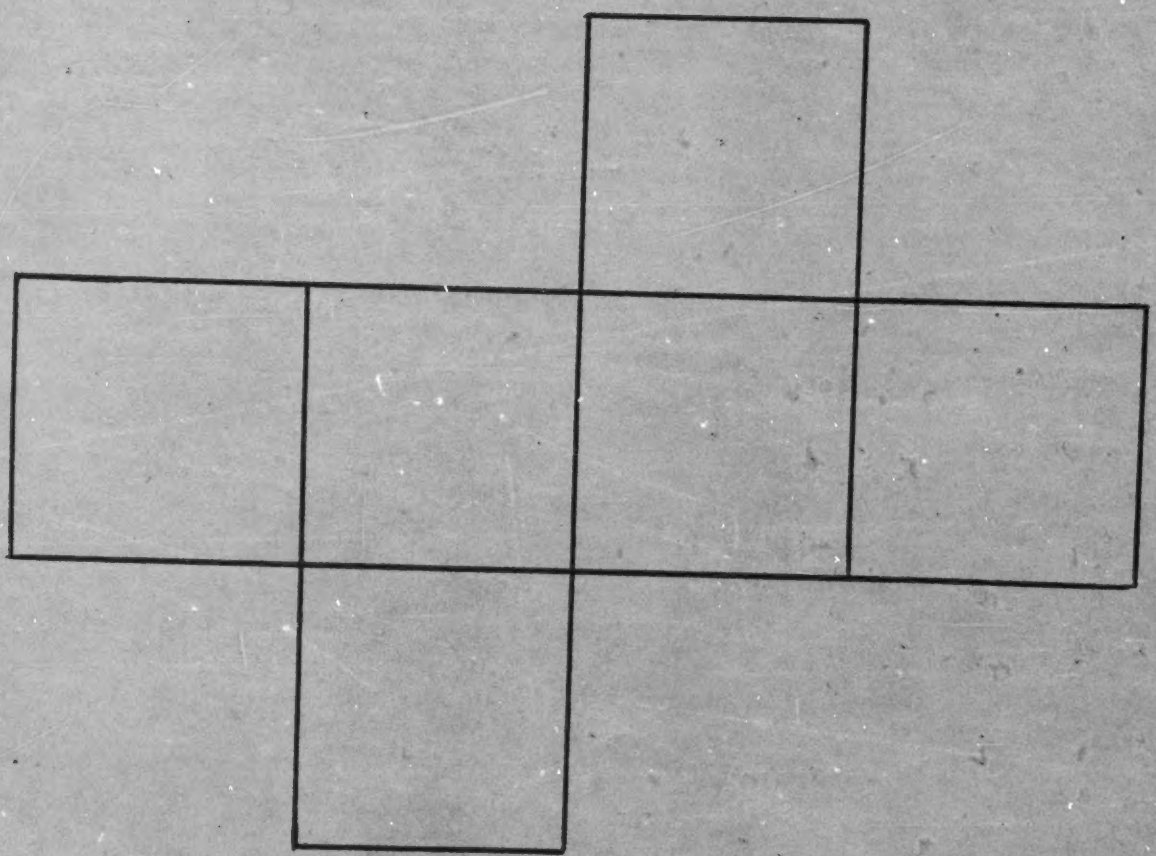
Prefixes

Names of multiples of SI and metric units are formed by using a prefix with "meter", "gram", "liter", "watt", or any other unit. Symbols use a prefix letter such as "ns" for nanosecond, "kHz" for kiloherts, "mV" for millivolt, etc.

giga	G	10^9	1 000 000 000	one billion
mega	M	10^6	1 000 000	one million
kilo	k	10^3	1 000	one thousand
hecto	h	10^2	100	one hundred
deka	da	10^1	10	ten
—	—	10^0	1	one
deci	d	10^{-1}	0.1	one tenth
centi	c	10^{-2}	0.01	one hundredth
milli	m	10^{-3}	0.001	one thousandth
micro	μ	10^{-6}	0.000 001	one millionth
nano	n	10^{-9}	0.000 000 001	one billionth
pico	p	10^{-12}	0.000 000 000 001	one trillionth

Appendix B

Suggested Diagram for Paper Cubes



Appendix C

Sources of Information

American National Standards Institute (ANSI), 1430 Broadway, New York, New York 10018.

Metric Editorial Guide, American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Guidelines for Writers of SI Metric Standards and Other Documents, Lou Perica, 1975, American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Guidance for Using the Metric System—SI Version, Valerie Antoine, Society of Technical Communication, 1010 Vermont Avenue, Washington, D.C. 20005.

Metric Practice Guide and Style Manual, National Bureau of Standards, from AMJ Publishing Company, Tarzana, California 91356.

Metric Guide for Educational Materials, American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

The International (SI) Metric System and How It Works, Robert Hopkins, 1974, Polymetric Services, Tarzana, California 91356.

American Metric Journal. Published bimonthly by AMJ Publishing Company, P.O. Box 696, Tarzana, California 91356.

Metric Bulletin. Published by J. J. Keller and Associates, Inc., 145 W. Wisconsin Avenue, Neenah, Wisconsin 54956.

Metric Reporter. Published biweekly by the American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Metric News. Published bimonthly by Metric News, Inc., 830 North 109th Street, Milwaukee, Wisconsin 53226.

A variety of Vocational-Technical Instructional Packages are available from the Center for Vocational Education, The Ohio State University, 1960 Kenny Road, Columbus, Ohio 43210.

Plan Ahead: Metrication and the U. S. Apparel Industry, 1975, American Apparel Manufacturers Association, 1611 North Kent Street, Arlington, Virginia 22209.

Moving Toward Metric: Insights into Consumerism, J. C. Penney Company, Inc.; "Purchasing Children's Clothing," L. C. K. Williams, U. S. Metric Study Interim Report, The Consumer, U. S. Department of Commerce, Washington, D.C.

Tables on Metric Conversion of Zipper Dimensions, Slide Fastener Association, 366 Madison Avenue, New York, New York 10017.

Educator's Guide to Metric for Clothing Construction, Coats & Clark, Inc., Consumer and Educational Affairs Department, P.O. Box 1966, Stamford, Connecticut 06904.

Hometrics Kit, Enrich, Inc., 760 Kifer Road, Sunnyvale, California 94086.

Metrics for Home Use, 1974, Opal Massey, Willow House Publishers, 111 N. San Joaquin Street, Stockton, California 95202.

An Educator's Guide to Teaching Metrication, Consumer Information Services, Sears, Roebuck and Company.

Going Metric, Channing L. Bete Company, Inc., 45 Federal Street, Greenfield, Maine 01301.

Metricook, Maple Leaf Mills, Ltd., 43 Junction Road, Toronto, Ontario.

Cooking the Metric Way, An Easy Guide to Good Nutrition, Mrs. Marjorie Taylor, 2268 Kensington Avenue, Burnaby, British Columbia V5B4E2.

Think Metric, Text No. 735M, 1973, Martin Instrument Company, 19450 Grand River Avenue, Detroit, Michigan 48223.

Thinking Metric, Thomas F. Gilbert and Marilyn B. Gilbert, John Wiley and Sons, Inc., 605 Third Avenue, New York, New York 10016.

Metric Equivalents (Catalog), Union Carbide Corporation, Educational Aids Department, P.O. Box 363, Tuxedo, New York 10987.

Metrics in the Kitchen, Mary Darling, Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101.

"Metric System, Nutrition Labeling, There's A New Way Coming," Food News for Boys and Girls, 1974, National Dairy Council, Chicago 60606.

"Metrication and the Consumer," Olive Batcher, Nutrition Program News, July-August, 1975, U. S. Department of Agriculture, Washington, D.C.

"The Home Economics Teacher and Metrics," (a correspondence course), Judy Oppert, Illinois Teacher of Home Economics, 1974, nos. 2, 3 and 4.

Articles on metrication in the Journal of Home Economics:

"Cooking with Grams," Marianna Z. Cochran, January, 1975, p. 31.

"Metrication and the Home Economist," Olive M. Batcher and Louise A. Young, February, 1974, p. 28.

"The Shift Toward Metric," Frances J. Parker, November, 1973, p. 15.

"Use of Matric Measurements in Food Preparation," Byron S. Miller and Henry B. Trimbo, February, 1972, p. 20.

"Start Now to Think Metric," Margaret Waring, December, 1972, p. 18.

"Report of the National Metric Study Conference--Consumer Affairs," May, 1971, pp. 345-349.

"Metric Measurements in Food Preparation," Phyllis E. Schlessinger and Barbara M. Kennedy, February, 1967, pp. 120-123.

Articles on metrication in the Canadian Home Economics Journal:

"Metric and Textiles," Mary Humphries, January, 1975, pp. 18-21.

"Metric Update," Wendy Sanford, April, 1976, pp. 23-25.

"Metric and Nutrition: The Kilojoule," Marilyn Small, January, 1976, pp. 26-28.

"Metric Cooking," CHEA Metric Committee, October, 1974, pp. 17-18.

"The Effect of Metric Conversion on the Consumer," Elizabeth P. Bond, American Metric Journal, September/October, 1975, pp. 21-23.

"Metrics: Your Schools Will Be Teaching and You'll Be Living It--Very, Very Soon," Philip G. Jones, American School Board Journal, July, 1973.

Sample Sources from which Exercises can be Formulated

Standard Textbook of Cosmetology, Alverna Ellington, 1972, Milady Publishing Corporation, Bronx, New York.

Cosmetologists State Board Exam Review Multiple Choice, Milady Staff, 1975, Milady Publishing Corporation, Bronx, New York.

Guide to Modern Meals, Dorothy E. Shang, Natalie K. Fitch and Pauline A. Chapman, 1964, Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011.

Food Service Careers Student Guide, Shirley B. Jalso and Jean A. Snyder, 1976, Charles A. Bennett Company, Inc., Peoria, Illinois 61614.

Professional Food Preparation, Margaret E. Terrell, 1971, John Wiley and Sons, Inc., 605 Third Avenue, New York, New York 10016.

Exploring Careers in Hospitality and Food Service, Cincinnati Public Schools Home Economics Department, 1975, McKnight Publishing Company, Bloomington, Illinois 61701.

Food Preparation Study Guide, Robert G. Haines, 1973, American Technical Society.

Appendix D

Standards Committees

ISO--The International Organization for Standards is an international, non-governmental agency for standards which is comprised of national standard bodies of about 80 nations.

ANSI--The American National Standards Institute is a federation of some 180 trade associations, technical societies, labor unions, and about 900 company members. ANSI is the U. S. member of ISO. ANSI does not write standards. It reviews and approves proposed standards written by committees administered by many technical and trade associations after all concerned groups have accepted them.

The address for ANSI is 1430 Broadway, New York, New York 10018. Current information about developments within specific trade associations is found in journals such as:

Metric News. Published bimonthly by Metric News, Inc., 830 North 109th Street, Milwaukee, Wisconsin 53226.

Metric Bulletin. Published monthly by J. J. Keller and Associates, Inc., 145 W. Wisconsin Avenue, Neenah, Wisconsin 54956.

Metric Reporter. Published biweekly by the American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

American Metric Journal. Published bimonthly by AMJ Publishing Company, P.O. Box 696, Tarzana, California 91356.

Answers

Pages 16-18

4. a. cm
   b. mm
   c. cm
   d. dm
   e. mm
   f. km
   g. m
   h. dm
   i. mm
   j. cm
   k. cm

5. a. 1 cm
   b. 5000 km
   c. 12 dm
   d. 15 cm; 15 cm
   e. 2.5 cm

6. a. 5600
   b. 5.6
   c. 3200
   d. 280
   e. 0.28
   f. 8
   g. 6.35; 635
   h. 5.8; 0.058
   i. 139
   j. $2\frac{17}{36}$; 89

7. $2.75

Pages 20-24

3.

Region	Calculated Area	Region	Calculated Area
1	8 cm^2	4	9.6 cm^2
2	8 cm^2	5	12.6 cm^2
3	57 cm^2		

6. a. m^2
   b. cm^2
   c. m^2
   d. cm^2
   e. dm^2
   f. cm^2
   g. m^2

7. a. 20 m^2
   b. 48 cm^2
   c. 28.8 m^2
   d. 209 m^2
   e. 175 000 m^2
   f. 88 920 m^2

8. a. 7400
   b. 60 000
   c. 1050
   d. 616
   e. 21
   f. 0.295
   g. 4.062 5
   h. 60

9. 4900; 9800

10. a. 0.45
    b. 15
    c. 1
    d. 2

11. a. 30 000
    b. 0.5
    c. 500
    d. 2.5
    e. 4

12. 3.6

13. 2.7

14. The window area is 1.12 m^2 but the material needed would be more like 4 m^2.

15. 4.63

16. 3.86

17. 335 dm^2

18. 1366 m^2

19. 13 500; 1.35

Pages 26-27

3. a. cm^3
   b. dm^3
   c. m^3
   d. dm^3

4. a. 2000
   b. 0.5
   c. 0.004
   d. 4
   e. 420
   f. 1491
   g. 102.4
   h. 0.186 321
   i. 144 000
   j. 0.144

5. 3000 cm^3

6. 75 000 cm^3

7. Varies

Pages 30-31

2. a. mL
   b. L
   c. mL
   d. L
   e. mL
   f. mL
   g. mL
   h. mL

3. a. 500 mL
   b. 750 mL
   c. 250 mL
   d. 90 mL
   e. 8 L
   f. 20 to 50 L

4. a. 1000
   b. 2
   c. 20
   d. 250
   e. 10 000
   f. L
   g. 1
   h. 2500

5. 100

6. 250

7. a. 18
   b. 5
   c. 250
   d. 18
   e. 0.0015
   f. 300
   g. 70 cm^3; 70

Pages 33-34

1. a. g
   b. g
   c. g
   d. mg
   e. mg
   f. kg
   g. kg
   h. g

2. a. 3 L
   b. 460 g
   c. 4.5 g

4. a. 0.750
   b. 1.45
   c. 0.5
   d. 2500
   e. 1 450 000
   f. 10 000

5. 89.25

6. 8

Pages 35-36

1. g

2. 15

3. 250 mL

4. 10; 1000

5. 10; 1000

6. 1

7. 1 kg

8. 1000

9. 2800 kg

10. About 4725 lb.

Pages 44-46

1. a. cm; cm
   b. mm
   c. cm
   d. cm
   e. dm^2
   f. cm; cm; cm
   g. g; g

2. Varies. For a table 38 cm by 75 cm the area is 2850 cm^2 = 0.2850 m^2.

3. 25

4. About 70 cm^2

5. 7.6

6. 40

7. 52 000 000

11. mg; mg

12. mL

14. kg; kg